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High-pressure catheter with a cutting and/or abrasion device

If water emerges at high pressure through a nozzle it can be used for cutting, and this effect was utilised by Japanese researchers for cutting hepatic tissue of a rat with a water gun or nozzle which had a diameter of only 0.2 mm, using 10 atm.g.

If these conditions are extrapolated to a pressure-tight catheter, called a high-pressure catheter by me, 17.5 atm.g. are necessary for this purpose according to calculations. Such high-pressure catheters can be inserted transluminally via the skin in stenosed or partially occluded pathways in the body, such as highly sclerosed coronary arteries, for the careful re-opening of pathological pathway occlusions and for removal of numerous stenoses.

If segmentally arranged nozzles, which are located obliquely rearwards and proximally on the nozzle head and form foci or coherent foci annularly, are used and if the foci of the nozzle jets project beyond the lateral outer edge of the nozzle head, an abrasion effect is obtained at the front of the high-pressure catheter in addition to the forward motion, and this should also be utilised for the production of effective curettes, for example for endometrial extraction.

High-pressure catheter with cutting and/or abrasion device

Claims

1. High-pressure catheter with cutting and/or abrasion device,
as well as for forward motion,
and also for re-opening pathway occlusions such as thrombi and for removing stenoses or pathway constrictions particularly in the case of the frequently occurring arteriosclerosis in various regions of the body and organs, such as the leg or heart,
characterised
in that sets of different-calibre high-pressure catheters are available for the percutaneously transluminally treating doctor,
in that this high-pressure catheter (1) has a nozzle head (2) at the front,
among these high-pressure catheters with a nozzle head there are ones which, by means of nozzles (3a) for cutting at the front of the nozzle head, Fig. 1, Figs. 2 and 3, serve for re-opening pathway occlusions, which is to be achievable by one or more nozzles directed forwards (3a) in the front part of the nozzle head using 17.5 atm.g., these nozzles (3a) also being able to form a focus (F4) axially in front of the nozzle head (2) to increase the jet effect,
in that other high-pressure catheters or high-pressure catheters with interchangeable nozzle head (2) contain laterally in the surface of the nozzle head nozzles (3a) (Fig. 4) which can likewise form foci (F4) beyond the surface edge of the nozzle head, with the result that it is

possible longitudinally to cut into pathologically altered, sclerosed and thickened vessel internal layers in the case of arteriosclerosis, particularly when advancing the high-pressure catheter or slowly withdrawing it, while preserving the musculature,
in that proximally directed nozzles for forward motion (3b) (Figs. 9, 10 and 11) of the high-pressure catheter are present at the rear part of the nozzle head (2),
in that such nozzles (3b) arranged, also segmentally annularly, at the rear part of the nozzle head can abrade rearwardly and in an obliquely lateral direction (Fig. 5), in particular when foci are formed at points or numerous foci in a ring by nozzle jets and so-called annular nozzles (3d) or parts thereof are used, in which case for abrasion the foci should extend beyond the lateral edge of the nozzle head (Fig. 5, F4),
in that, to conform to conventional catheter forms, such high-pressure catheters each have in the nozzle head a system-medium-controlled nonreturn valve (Figs. 19, 19a and b) with a spring (27), guide body (26) and closure plate (25) with stroke-dependent cross-sectional narrowing (30) at the front of the nozzle head and a relatively wide lumen (Fig. 19) being present there, making possible injection, aspiration, blood-pressure measurement and other procedures at pressure 0 or low pressure up to about 1 atm.g.,
in that each of these high-pressure catheters (1) can be connected proximally to the main pressure line (12) of the pressure tank (14) for fluid by a connecting piece (11) which is easy to handle and yet strong,
in that this pressure tank (14) for fluid has a Teflon valve (13) against air embolism, as well as further fittings such as a manometer (15), filling funnel (17),

safety valve (21), and the pressure tank (14) receives pressure from a pump gradually via a further valve (16).

2. High-pressure catheter with cutting and/or abrasion device according to Claim 1, characterised in that the nozzle head (2) consists of heavy metal such as platinum or gold, whereby basic control at the front of the catheter also inside the body is possible using the force of gravity.

3. High-pressure catheter with cutting and/or abrasion device according to Claim 1-2, characterised in that the nozzle head (2) also consists of other solid materials such as plastic.

4. High-pressure catheter with cutting and/or abrasion device according to Claim 1-3, characterised in that one or more nozzles (3a), forwardly directed, for cutting are present in the front part of the nozzle head (2) (Figs. 1 and 2).

5. High-pressure catheter with cutting and/or abrasion device according to Claim 1-4, characterised in that, as in Fig. 2, the front nozzles (3a) with nozzle jets emerging there in front of the nozzle head (2) form a focus (F4), particularly suitable for careful vessel opening in a pathologically closed pathway.

6. High-pressure catheter with cutting and/or abrasion device according to Claim 1-4, in particular Claim 5, characterised in that the front part of the nozzle head (2) has an indentation axially in the region of the nozzles (3a), so

that the focus (4) is shielded by the front lateral parts of the nozzle head and wounds to lateral original parts of the pathway, such as the actual vessel wall, cannot occur.

7. High-pressure catheter with cutting and/or abrasion device according to Claim 1-6, characterised in that the nozzles for cutting (3a) are offset by 90° with respect to the nozzles present hitherto in the front part of the nozzle head, i.e. laterally, also for focus formation (F4), in the lateral surface of the nozzle head and are likewise suitable for cutting, whereby in particular the hardened and thickened internal wall layers of the arteriosclerosis can be longitudinally opened upon withdrawal or forward motion of the high-pressure catheter, and thereby also dilatation lines can be created for subsequent dilatation while preserving the important musculature of the vessel pathway (Fig. 4).

8. High-pressure catheter with cutting and/or abrasion device according to Claim 1-7, characterised in that such nozzles (3b) with focus formation (F4) are present at the rear laterally on the nozzle head (2), likewise for cutting or abrading, as well as for forward motion, so that an abrasion device is obtained (Fig. 5), it being necessary for the foci also to project annularly beyond the lateral edge of the nozzle head.

9. High-pressure catheter with cutting and/or abrasion device according to Claim 1-7, in particular Claim 8, characterised in that, in the case of such an abrasion device, which is furthermore also suitable for extracting endometrium, the rear part of the high-pressure catheter merges into a

handle for better handling of the entire device, and similarly, physiological saline is used as the fluid for abrading inside the uterus.

10. High-pressure catheter with cutting and/or abrasion device according to Claim 1-9, characterised in that the front part of the high-pressure catheter for abrasion in the uterus or for similar purposes also in other pathways such as Vater's papilla has longitudinal ribs on the outer surface of the high-pressure catheter or the pressure tube behind the nozzle head, in order to prevent fluid accumulation or ballooning.

11. High-pressure catheter with cutting and/or abrasion device according to Claim 1-7, in particular Claims 8-10, characterised in that the nozzle head (2) of an abrasion device wholly or largely comprises a hardly dilatable rubber casing and, in the rear lateral part of the same for severing endometrium, focus-forming, cutting nozzles (3b), in particular annular nozzles (3d), are present.

12. High-pressure catheter with cutting and/or abrasion device according to Claim 1-7, where in particular Claims 8-11 should be taken into consideration, characterised in that via a high-pressure tube led through the working duct of an endoscope, such a small-calibre abrasion device is advanced, for example in the case of papillomatosis in a ureter, likewise for abrasion, to remove the papillomas.

13. High-pressure catheter with cutting and/or abrasion device according to Claim 1-12, characterised

in that also a larger-calibre abrasion device for removing massive thrombosis, such as occurs also in the aorta, is used, along with a collecting device composed of a fine metal net which is placed over the nozzle head (2) and in which the removed portions of thrombi or else tissue parts of the advanced arteriosclerosis collect, so that thromboembolisms or tissue embolisms do not occur.

14. High-pressure catheter with cutting and/or abrasion device according to Claim 1-13, characterised in that such high-pressure catheters with nozzle head (2) at the front are also passed through working ducts of endoscopes, for cutting, abrading, milling, if a turbine (7) is used as part of a nozzle head (2) for milling, and also for forward motion.

15. High-pressure catheter with cutting and/or abrasion device according to Claim 1-14, characterised in that such a high-pressure catheter with nozzle head (2), advanced for various functions in the pathway, is controlled in its action by an endoscope being introduced in addition.

16. High-pressure catheter with cutting and/or abrasion device according to Claim 1-15, characterised in that nozzles are arranged linearly in the manner of a knife at the front of the nozzle head (2) of a high-pressure catheter, for cutting (3a).

17. High-pressure catheter with cutting and/or abrasion device according to Claim 1-16, characterised in that the nozzles (3a) are arranged axially circularly at the front of the nozzle head (2), with a small or larger

diameter, so that whole tissue cylinders or if the nozzles (3a) converge conical thicker tissue slices are cut out.

18. High-pressure catheter with cutting and/or abrasion device according to Claim 1-17, characterised in that the lateral part of a nozzle head contains circularly arranged nozzles (3a), also with focus formation (F4), so that conical tissue pieces are then cut out perpendicularly to the axis of the pathway.

19. High-pressure catheter with cutting and/or abrasion device according to Claim 1-18, characterised in that nozzles (3a) or sectors of annular nozzles (3d) are present laterally on the nozzle head in a plurality of planes perpendicularly to the longitudinal axis of the high-pressure catheter nozzle head (2), the jets of which nozzles meet one another, so that partial or complete annular pathway tissue detachments are possible.

20. High-pressure catheter with cutting and/or abrasion device according to Claim 1-19, characterised in that a hook, Fig. 16, which has to be open on one side (24), is formed at the front by a flattened nozzle head, the inside of this hook having numerous individual nozzles (3a) or else slot-shaped nozzles (23), lying in one plane, with focus formation (F4), so that particularly polyps caught by the hook can be easily detached.

21. High-pressure catheter with cutting and/or abrasion device according to Claim 1-20, characterised in that a fork is formed by a nozzle body of flat design and the inner parts of the branches contain nozzles (3a) in

the same plane, with focus formations (F4) of the jets emerging there, which increases the cutting action.

22. High-pressure catheter with cutting and/or abrasion device according to Claim 1-21, characterised in that the front part of a high-pressure catheter narrows conically and has at the front a nozzle head (2) with a diameter less than 1 mm for forward motion, with rearwardly positioned nozzles (3b), so that the front part of this high-pressure catheter can advance far into the also sclerosed vessel periphery for anchoring as it were, in particular if the nozzle head consists of platinum, additionally a platinum filling is also present on the nozzle body (2) and the force of gravity inside the body is utilised.

23. High-pressure catheter with cutting and/or abrasion device according to Claim 1-22, characterised in that such a narrow high-pressure catheter advanced far into the vessel periphery and having a platinum filling at the front becomes a guiding path for a balloon catheter, pushed on from proximally, of conventional type or of the novel form with double-lumen nozzle body (22) behind the balloon (20) with a central nozzle obstructed by the high-pressure catheter.

24. High-pressure catheter with cutting and/or abrasion device according to Claim 1-23, characterised in that the high-pressure catheter is partially endowed with properties of the conventional guiding catheter (10) by its front part being preformed with a relatively wide calibre, and by the nozzle head (2) at the front frontally containing a wide nozzle, adjustable from proximally by

wire and cone, so that after forward motion such as into the stems of a coronary artery, small-calibre further implements can be inserted into the pathologically altered pathway of the body through this relatively wide catheter (primarily high-pressure catheter) now also wide open at the front, for dilatation, cutting/opening, removal of a thrombosis/thromboembolism, for milling and for removal of stenoses.

25. High-pressure catheter with cutting and/or abrasion device according to Claim 1-24, characterised in that a balloon (20) is situated coaxially on the front part of the high-pressure catheter and receives fluid from proximally for dilatation in pathway stenoses.

26. High-pressure catheter with cutting and/or abrasion device according to Claim 1-25, characterised in that in particular according to Claim 25 this high-pressure catheter with balloon (20) becomes thicker in a step proximally behind the balloon, and in the surface of the high-pressure catheter at that place, i.e. behind the balloon (20), a plurality of fine pressure lines are situated for dilatation.

27. High-pressure catheter with cutting and/or abrasion device according to Claim 1-26, characterised in that the high-pressure catheter has <u>proximally</u> a connecting piece (11) which does <u>not</u> project laterally beyond the outer surface of the high-pressure catheter, so that a balloon catheter can be pushed on proximally (Fig. 7).

28. High-pressure catheter with cutting and/or abrasion device according to Claim 1-27, characterised in that the nozzle head (2) is <u>asymmetrically</u> designed with nozzles (3b) directed predominantly rearwards for forward motion (Fig. 15).

29. High-pressure catheter with cutting and/or abrasion device according to Claim 1-28, characterised in that the high-pressure catheter with <u>asymmetrical nozzle head</u> (2) at the front can be additionally <u>rotated</u> in the pathway of the body, for which a rotatable and nevertheless sealing-off connecting piece (11) to the main pressure line (12) is required.

30. High-pressure catheter with cutting and/or abrasion device according to Claim 1-29, characterised in that a vibrator/vibrators can be coupled to the rear part of such a high-pressure catheter to further reduce the friction in the pathway of the body.

31. High-pressure catheter with cutting and/or abrasion device according to Claim 1-30, characterised in that an axially positioned front nozzle (3a) is redesigned to form a microturbine to be axially impinged by means of a screw-shaped internal design, so that upon fluid impingement rotation of this microturbine at the front of the nozzle head (2) results, with a boring action and simultaneously flushing.

32. High-pressure catheter with cutting and/or abrasion device according to Claim 1-31, characterised in that the front part of the nozzle head (2) axially contains a larger nozzle which has to be closed by a

conical or similar closure body at least upon forward motion, the closure is then to be removed at a suitable place in the body, so that the catheter lumen is now free along the entire length for the introduction of other medical instruments in the manner of a guiding catheter.

33. High-pressure catheter with cutting and/or abrasion device according to Claim 1-32, characterised in that the surface of such a high-pressure catheter has longitudinal ribs, particularly when it is used for abrasion in the uterus or at another place in the body, so that, as a result of tissue being lifted off thereby from the surface of the high-pressure catheter, fluid emerging at the front of the nozzle head (2) can flow out better in the proximal direction, even with detached tissue particles such as mucous membrane.

34. High-pressure catheter with cutting and/or abrasion device according to Claim 1-33, characterised in that the nozzle head (2) has distally (at the front) a valve controlled by the pressure liquid (Fig. 19).

35. High-pressure catheter with cutting and/or abrasion device according to Claim 1-34, characterised in that the valve (Fig. 19) at the front of the nozzle head (2) is open at normal pressure (atmospheric pressure) or at a low pressure up to about 1 atm.g., but then closes automatically at higher/high pressure, so that the nozzles (3a and b) at the nozzle head (2) can be acted upon for different functions such as forward motion, cutting or abrasion.

36. High-pressure catheter with cutting and/or abrasion device according to Claim 1-33, in particular in relation to Claims 34 and 35, characterised in that a forwardly directed nozzle/nozzles (3a) is/are present in the plate, bringing about the closure, of a valve controlled by the pressure liquid, and thus even with this arrangement cutting open is still possible at the front of the nozzle head in the pathway.

37. High-pressure catheter with cutting and/or abrasion device according to Claim 1-36, characterised in that nozzles (3) are present in the high-pressure catheter wall (1) on the outside and directed in the proximal direction, Figs. 20a and b, which nozzles each utilise pressure difference for direct control of microvalves, a widening being present in the obliquely outwardly directed nozzle duct close to the catheter lumen, with a ball which is fastened in the direction of the catheter lumen to the inner layer of the catheter wall by a spring/a plurality of springs, so that only at higher pressure, for example 1 atm.g., or higher pressure inside the catheter, with the ball being pushed away, can fluid emerge through this nozzle (3) situated in the wall of the catheter (1) for improved sliding, for forward motion or flushing, Figs. 20a and b.

High-pressure catheter with cutting and/or abrasion device

The invention relates to a high-pressure catheter with cutting and/or abrasion device, as well as for forward motion, and also for re-opening pathway occlusions and for removing stenoses or pathway constrictions particularly in the case of the frequently occurring arteriosclerosis in various regions of the body and organs, such as the leg or heart.

Such stenoses and also pathway occlusions of various kinds particularly in the arterial vascular system, such as the coronary arteries, require urgent careful medical removal.

References: Peter Satter: Die rettende Herzoperation: der Bypass (The saving heart operation: the bypass), Zeitschrift der Deutschen Herzstiftung, issue 5.

Motoki Yonekawa et al.: "Water Gun" safer than scalpel developed here, Tokyo daily newspaper, 15th week 1984.

Andreas R. Grüntzig: Transluminale Koronardilatation - Bestandsaufnahme und Ausblick (Transluminal coronary dilatation - taking stock and outlook), Deutsches Ärzteblatt, issue 38, 1983.

W. Kindermann, Dipl.-Ing.: Kraftwerkunion Mühlheim-Ruhr, letter of 01.06.19

Gisbert Kober: Die neue Behandlungsmethode : Ballondilatation (The new treatment method: Balloon dilatation), Zeitschrift der Deutschen Herzstiftung, issue 3, 1983, Frankfurt/Main.

Schneider Medintag AG: Product information on Grüntzig Dilaca, coronary dilatation, February 1982.

Patent specifications Werner Schubert:

DE 31 11 497 C2 "Vorrichtung zum Einführen von medizinischen Instrumenten, Kathetern, Sonden oder dgl. in Körperhohlorgane und Gefäße" ("Device for introducing medical instruments, catheters, probes or the like into hollow organs of the body and vessels"),

US application serial number 361,117.

P 33 20 076.9-35 "Turbinen zum Betreiben von Kleinstmaschinen am vorderen Teil von medizinischen Sonden, Kathetern oder dergleichen sowie zur Vorwärtsbewegung" ("Turbines for operating micromachines at the front part of medical probes, catheters or the like, and also for forward movement").

P 33 26 648.4 "Katheter mit verstellbarer Frontdüse und Ballon" ("Catheter with adjustable front nozzle and balloon").

P 34 02 573.1 "Ballondilatationsvorrichtung mit Schneidewerkzeug am primär einlumigen Mehrzweckkatheter" ("Balloon dilatation device with cutting tool on a primarily single-lumen multipurpose catheter").

P 34 08 809.1 "Vorrichtung am Katheter zur besseren Beseitigung von Leitungsbahnstenosen" ("Device on a catheter for improved removal of pathway stenoses").

Prof. Dr. Ing. K. Kauder, College of Advanced Technology of the University of Dortmund, expert opinion of 16 May 1984. American hospital supply Corporation, Chicago "New linear extrusion balloon dilatation" (1984).

The current balloon catheter is technically not adequate for more extensive tasks, as well as for removing vessel occlusions. The bypass operation, with the prerequisite of opening the thoracic cavity and the pericardium, using vessels as bypasses is a complex and expensive procedure, which is not without complications either. I am also aware of attempts using ultrasonic probes to re-open thrombotic occlusions in the vessel; conducted laser energy is also possible for this. But these are also complex procedures which have not gained any practical importance for this purpose.
Important data were provided, inter alia, by the above-mentioned Japanese researcher and also Prof. K. Kauder as a fluid engineer. For the water gun or the novel scalpel, 10 atm.g. was used when cutting hepatic tissue of a rat with a nozzle diameter of 0.2 mm. A catheter inside diameter of 1 mm was taken as a basis by Professor Kauder for his calculations.

In order to obtain sufficient impulse forces for movability of the catheter and also for therapeutic measures for improved removal of pathway stenoses, a gauge pressure of 17.5 atm.g. would be required at a mass flow m (9/s) 10, a mean flow rate c (m/s) likewise 10 and the impulse force F_j (N) 10^{-1}.

The object on which the invention is based is to be able, by means of high-pressure catheters/ different-calibre high-pressure catheters, to cut and/or abrade carefully by means of **nozzles** as far as possible inside the body in pathways as well as in arteriosclerotically altered vessels also of the heart or in other regions of the body. The conventional curette even for the uterus with an annular cutting device at the front is still too wide and usually requires an anaesthetic. Currently existing abrasion devices for the same purpose, approximately 4 mm wide, produce too little mucous membrane.

This object is achieved according to the invention in that sets of different-calibre high-pressure catheters are available for the percutaneously transluminally treating doctor,

in that this high-pressure catheter has a nozzle head at the front,

among these high-pressure catheters with a nozzle head there are ones which serve for re-opening pathway occlusions, which is achieved by one or more nozzles directed forwards in the front part of the nozzle head for cutting using high fluid pressure, these nozzles being able to form a focus axially in front of the nozzle head to increase the jet effect,

in that other high-pressure catheters or high-pressure catheters with interchangeable nozzle head contain laterally in the surface of the nozzle head nozzles which can likewise form foci beyond the surface edge of the nozzle head, with the result that it is possible longitudinally to cut into pathologically altered, sclerosed and thickened vessel internal layers in the case

of arteriosclerosis, particularly when advancing the high-pressure catheter or withdrawing it,
in that proximally directed nozzles for forward motion of the catheter are present at the rear part of the nozzle head,
in that such nozzles arranged, also segmentally annularly, at the rear part of the nozzle head can abrade rearwardly and in an obliquely lateral direction, in particular when foci are formed at points or numerous foci in a ring by nozzle jets and so-called annular nozzles are used, in which case for abrasion the focus/foci should extend beyond the lateral edge of the nozzle head,
in that, to conform to conventional catheter forms, such high-pressure catheters each have in the nozzle head a system-medium-controlled nonreturn valve with a spring, guide body and closure plate with stroke-dependent cross-sectional narrowing at the front of the nozzle head and a relatively wide lumen (Fig. 19) being present there, making possible injection, aspiration, blood-pressure measurement and other procedures at pressure 0 or low, adjustable pressure, optionally up 1 atm.g.,
in that each of these high-pressure catheters can be connected proximally to the main pressure line of the pressure tank for fluid by a connecting piece which is easy to handle and yet strong,
in that this pressure tank for fluid has a Teflon valve against air embolism, as well as further fittings such as a manometer, safety valve, and the pressure tank receives pressure from a pump gradually via a further valve.

Claims 2-37 should be referred to with regard to further development.

Advantages:

All these high-pressure catheters even of different calibre, each having a nozzle head at the front, can be carefully advanced via the skin and pathway or the vessel lumen transluminally to the site of the disease, at which stenoses or even an occlusion are situated. Axial cutting open of occlusions by means of high water pressure via a nozzle is thus possible even far into the pathway of the body, such as in the coronary arteries, so that some bypass operations become unnecessary. With a high-pressure catheter of only about 0.7 mm width at the front and having a nozzle head, it is possible to reach far into the vessel periphery much better than with conventional catheters, especially as during the time of the forward motion liquid of the fluid which has flowed out as it were surrounds the nozzle head, which is blunt anyway.
If nozzles are radially situated on the side of the nozzle head, it is possible, in a manner limited with regard to depth action, to cut open the sclerosed and thickened arteriosclerotic vessel internal wall layer by advancing the high-pressure catheter or slowly withdrawing it longitudinally, which is useful for the dilatation of the constricted vessel lumen.
Additional mechanical action by advancing the relatively thick-walled high-pressure catheter can furthermore produce additional dilatation and also better path finding in the, also branched, pathway, promoted also by rotation of an asymmetrical nozzle head. Thin high-pressure catheters of this kind can be advanced far into the vessel periphery, and also become a guiding path for a balloon dilatation catheter to be pushed on.

A type of anchoring in the vessel periphery by a far-advanced thin high-pressure catheter with a nozzle head made of platinum and as far as possible also a platinum filling utilising the force of gravity could lead, in the heart wall, to a "permanent catheter" for therapy and/or diagnostic measures. The production of such nozzle heads, which are usually composed of metal, is not difficult and actually not costly either. A standard connecting piece to the main pressure line can be produced for all high-pressure catheters even of different calibre. Such high-pressure catheters with rearwardly and laterally positioned nozzles on the nozzle head, the foci of which already project laterally beyond the outer edge of the nozzle head, can bring about forward motion and at the same time abrasion, promoting the removal of stenoses in vessels; the same principle modified with nozzles at the front of the high-pressure catheter, for example as a uterine curette, can be employed to extract mucous membrane, optionally also at other places in the body.

Higher pressures upon the impingement of a high-pressure catheter provide the possibility of using the system medium to control a nonreturn valve in the nozzle head, as shown by Fig. 19. Thus, the use of such a nonreturn valve at the front of the high-pressure catheter provides the possibility, as with the conventional catheter, for injection, aspiration, blood-pressure measurement and other procedures, with a relatively wide lumen at the front when 0 pressure or low pressure is present in the high-pressure catheter.

Further advantages emerge from Claims 2-37.

When using such a high-pressure catheter, particular care should presumably be taken to ensure that such a catheter does not remain for a prolonged time in the pathway of the body with fluid flowing out. The amount of blood in a human is 5-6 litres; with narrow nozzles and emerging fluid, pronounced clinically significant dilution of the blood, hydraemia, cannot occur within a short time. Very fine distribution of pathological alterations such as thrombi in the vessel lumen, which can be achieved within a short time especially by high water jet pressure, is better tolerated by the body's circulation than if larger particles are set in motion. When using high-pressure catheters with a nozzle head for abrasion, for example in the uterus, at least flat longitudinal ribs should be present on the outer surface of the front part of the catheter, in order to enable better return flow for fluid that has emerged, preventing ballooning. (This principle has already been mentioned in DE 31 11 497, C2).

Drawing:

Fig. 1 shows in longitudinal section a nozzle head (2) with only one forwardly directed nozzle (3a) (front nozzle) for cutting at the front (frontally) on the high-pressure catheter (not depicted).

Fig. 2 shows the longitudinal section through another nozzle head (2) with concentrically arranged front nozzles (3a), the fluid jets forming a focus (F4) in front of the nozzle head for cutting.

Fig. 3 shows the longitudinal section of a nozzle head as Fig. 2 with front nozzles (3) directed concentrically at a

focus (4), and furthermore a suction device by means of a double tube with connection to the pathway of the body at the level of the front part of the nozzle head (6).

Fig. 4 shows the longitudinal section through a nozzle head (2) with a cutting device likewise operated by fluid, but now in the cylindrical lateral surface of the nozzle head with nozzles (3a) directed concentrically at a focus (F4), in order to be able longitudinally to open sclerosed and thickened vessel internal wall layers, for example; Fig. 4 additionally shows nozzles at the rear part of the nozzle head directed rearwards for forward motion.

Fig. 5 shows the longitudinal section through a nozzle head (2) or an abrasion device on the high-pressure catheter, in whose rear lateral part there are a plurality of focus-forming nozzles for cutting or abrasion (3b) and also at the same time for forward motion, it being of importance for the abrasion that the foci formed by nozzle jets are already located laterally outside the surface edge of the nozzle head for the abrasion.

Fig. 6 shows the redesign of the front part of a nozzle head (2) to form a turbine (7), which upon radial impingement advantageously rotates about a relatively widely dimensioned hollow axle and whose front outer surface has at least fine friction teeth for a milling cutter (7a), and nozzles for propulsion (3b) may also be present proximally on the nozzle head.

Fig. 7 shows in longitudinal section the entire fluid-operated device with high-pressure catheter and at the front a nozzle head (2) optionally for opening or re-

opening a hitherto occluded pathway, this high-pressure catheter having already been advanced through the guiding catheter (10) into the inside of the body, with a connecting point (11) to the main pressure line (12), and the main pressure line again being connected via a Teflon valve (13) to the high-pressure tank (14), this high-pressure tank also being connected via a valve (16) to a pump and furthermore having a manometer (15), a closable connecting branch (17) and a safety valve (21).

Fig. 8 shows in longitudinal section a balloon catheter of new form, which has been pushed over a high-pressure catheter advanced far into the vessel periphery, <u>with a double-lumen nozzle body (22) behind the balloon (20)</u>, so that ample fluid of the low-pressure region is available for the balloon, for which purpose a second low-pressure pump is recommended. The main nozzle (22) behind the balloon (20) is closed by the narrow high-pressure catheter used as a guiding path. The remaining free rear envelope-shaped space for fluid must be closed by rubber collar (18) and clamp before balloon dilatation. Situated at the front of the high-pressure catheter, for forward motion and anchoring, is a nozzle head (2) made of platinum, which has rearwardly directed nozzles (3b).

Fig. 9 shows the longitudinal section of a conventional nozzle head (2) on the high-pressure catheter for forward motion with rearwardly directed nozzles (3b).

Fig. 10 shows the longitudinal section of a nozzle head (2) with annular nozzle (3d), likewise with a rearwardly directed circular nozzle jet for <u>forward motion</u>.

Fig. 11 shows the longitudinal section of a nozzle head (2) with a platinum filling at the front, likewise for forward motion, whereby basic control is possible also inside the body by utilising the force of gravity.

Fig. 12 shows the cross-section of a nozzle head (2) with wedge-shaped attachments (9) on its outer surface (1) for slitting hardened and thickened vessel wall internal layers, such as in arteriosclerosis, to promote the careful dilatation of internal pathologically solidified and thickened vessel wall layers.

Figs. 13 and 14 show a thin (Fig. 13) and approximately twice as thick high-pressure catheter for forward motion, each in a guiding catheter (10) of equal thickness, having an inside diameter of about 2 mm. Fig. 13 additionally shows, at the front part, narrowing slightly conically at the front, of this slender high-pressure catheter, on the front part of the conical narrow shaft, longitudinal fine wedge-shaped cutting devices (9), in order to be able longitudinally to cut into hardened and usually, at the same time, thickened vessel wall internal layers, also for improved dilatation.

Fig. 15 shows the longitudinal section of an asymmetrical nozzle head with predominantly proximally directed nozzles (3b) for forward motion at the front part of a high-pressure catheter. The forward-movement forces to be obtained in the pathway of the body have been indicated by arrows, as has the simultaneously possible boring rotation of the asymmetrical nozzle head on the high-pressure catheter about the longitudinal axis to improve penetration into even narrow residual lumina and also for subsequent

dilatation. This asymmetrical nozzle head should also be of use for guidance, to bring the front part of the high-pressure catheter into a vessel branch.

Fig. 16 shows the longitudinal section through a hook-shaped nozzle head (2) on the high-pressure catheter with largely mutually oppositely directed nozzles (3) lying in one plane, resulting in fluid jets for cutting off polyps or a similar cutting action.

Fig. 17 shows the plan view of the outlet points of a plurality of linearly arranged cylindrical nozzles (3), a. b shows the plan view of slot-shaped nozzles (23) likewise linearly arranged, also for cutting. c shows such an annular nozzle (3d), with which fluid cutting using high pressure is likewise possible.

Fig. 18 shows the graphic symbol of the international standard ISO 1219 1, edition 1979, for a system-medium-controlled valve, which, as illustrated in section in

Figs. 19 and 19a and b, is a nonreturn valve in the nozzle head of a high-pressure catheter. The long spring with a small spring constant (27) has axially an abutment (28), B B′, also Fig. 19b, still proximally on the nozzle head (2), by means of three obliquely set-back struts; ample fluid from the high-pressure catheter enters the nozzle head (2) through the sector-like large gaps present between the struts. The front part of the spring (27) is connected to the actual longitudinally forwardly or rearwardly movable nonreturn valve. Fig. 19 shows this nonreturn valve in the open position, i.e. drawn back, so that conventional injection can take place, since in this

case, compared to 17.5 atm.g., only small compressive forces arise during injection (up to 1 atm.g.) and thus the spring tension is sufficient to maintain the closure plate (25) in the open position. The struts A and A', also Fig. 19a, as parts of an apertured disc positioned perpendicular to the longitudinal axis, serve for tilt-free valve guidance (26). Situated at the front of the nozzle head (2) to the side of the valve plate (25) is the stroke-dependent cross-sectional narrowing (30), which in the actual lower-pressure region as on the conventional catheter enables aspiration, blood-pressure measurement and other procedures, as well as the actual medical injection frequently performed. When the nonreturn valve is subjected to high impingement and is then automatically closed, controlled by the system medium, forward motion is produced at the front of the high-pressure catheter, and, when fluid jets (3b) are also set behind one another and directed concentrically towards one another, at the same time abrasion is produced. Given the same conditions of the automatic valve closure at 17.5 atm.g., a cutting action is also obtained at the front of the nozzle head (2) of the high-pressure catheter, in order to be able efficiently to remove occluding thrombi for example of an occluded vessel (3a).

Figs. 20a and b show the high-pressure catheter wall (1) with nozzle (3) embedded therein in hobnail fashion and directed obliquely rearwards, likewise for improved sliding and forward motion in the pathway of the body, with fluid-controllable built-in simple ball valve and spring tensioning of this ball valve and with the attachment point of the spring in the region of the inner layer of the catheter wall. Only at higher pressures, after substantial

forward motion of the front part of the high-pressure catheter by means of the nozzle head (2), do the valves/valve open, these valves being embedded therebehind in the high-pressure catheter wall (1), directly controlled by pressure difference and situated in the nozzles directed rearwards or more transversely to the longitudinal axis of the catheter.

<u>Key</u>:

1	-	wall of the high-pressure catheter
2	-	nozzle head
3a	-	nozzle/nozzles for cutting
3b	-	nozzle/nozzles for forward motion and abrading
3c	-	nozzles on a turbine
3d	-	annular nozzle
4	-	focus by jets from differently shaped nozzles
5	-	cylindrical-envelope-shaped suction extraction duct
6	-	outer double tube for suction extraction
7	-	radially impinged turbine, the front part of which is shaped to form a
7a	-	milling cutter
8	-	a plurality of differently shaped nozzle bodies on the high-pressure catheter for forward motion and abrasion with rearwardly directed nozzles
		Fig. 6 - known nozzle head composed of a solid metal body
		Fig. 7 - nozzle head with so-called annular nozzle
		Fig. 8 - nozzle head weighted at the front by platinum filling
9		Fig. 9 - lateral conical cutting devices of the nozzle head
10	-	<u>guiding catheter</u>
11	-	connecting piece to the fluid main pressure line without projecting beyond the diameter of the outer surface of the rear part of the catheter.
12	-	high-pressure line
13	-	Teflon float valve
14	-	pressure tank with fluid

15 - manometer

16 - supply line with closure device to the pump

17 - filling funnel for pressure tank

18 - collar-shaped closure at the rear part of the balloon catheter

19 - connecting branch for balloon dilatation

20 - balloon of a catheter which has been pushed over a high-pressure catheter advanced into the pathway of the body.

21 - safety valve

22 - nozzle body behind the balloon

23 - slot-shaped nozzles, also suitable for cutting

24 - nozzle head shaped flat into a hook, with nozzles (3) directly radially at the central part of the hook

25 - valve plate

26 - tilt-free valve guidance, A - A′, also Fig. 19a

27 - long tension spring with small spring constant

28 - proximal spring abutment still part of the nozzle head, B B′, also Fig. 19b

29 - screw connection of the nozzle head to the front part of the high-pressure catheter

30 - stroke-dependent cross-sectional narrowing

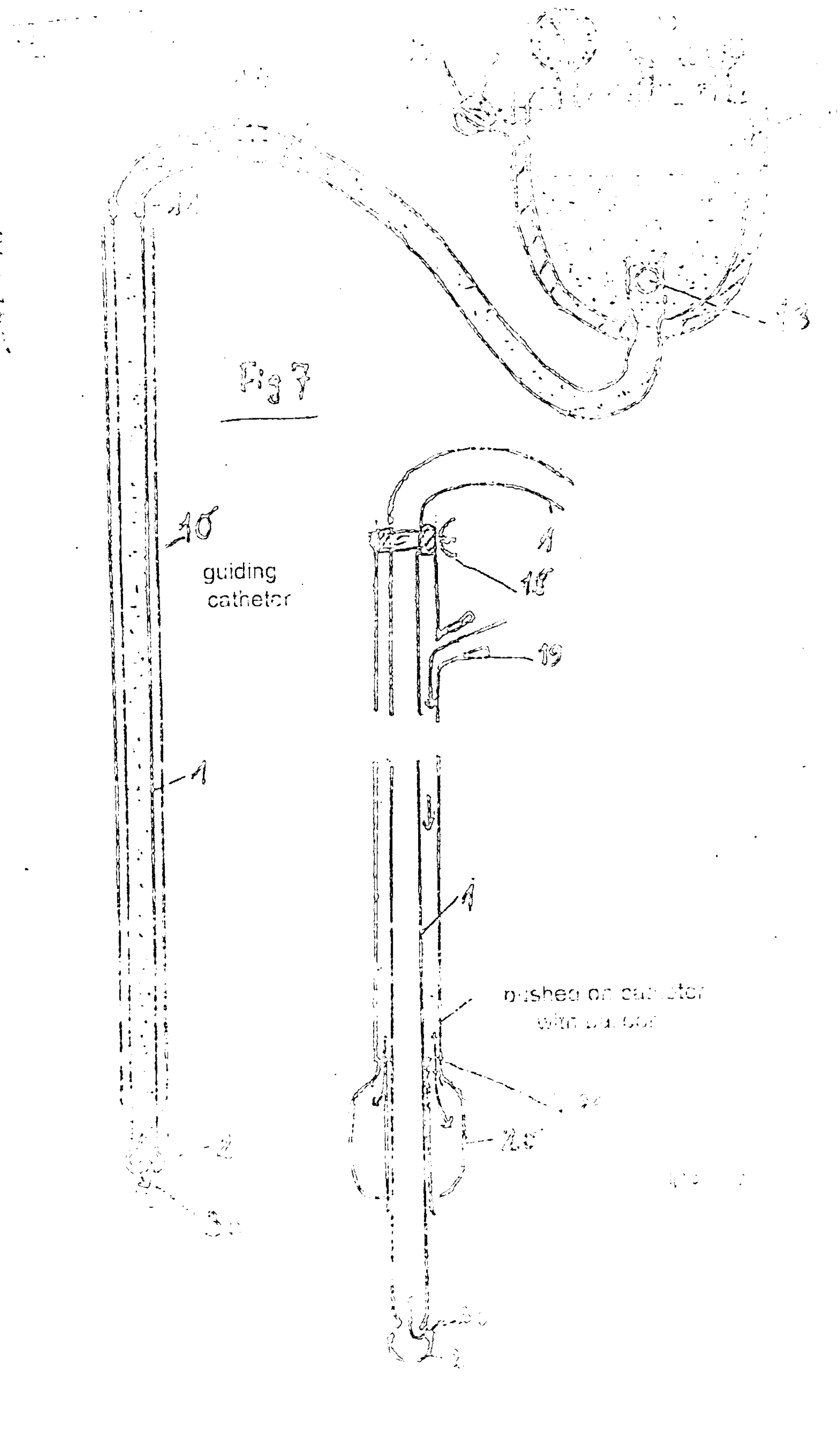


Fig 7
10
guiding catheter
1
4
18
19
1
2
13

Fig. 9

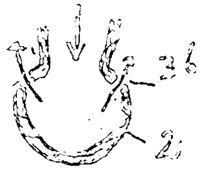


Fig. 10

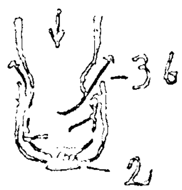


Fig. 11

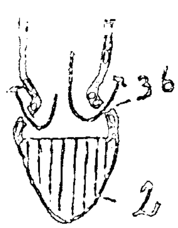
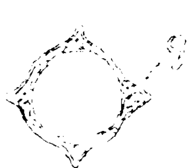


Fig. 12



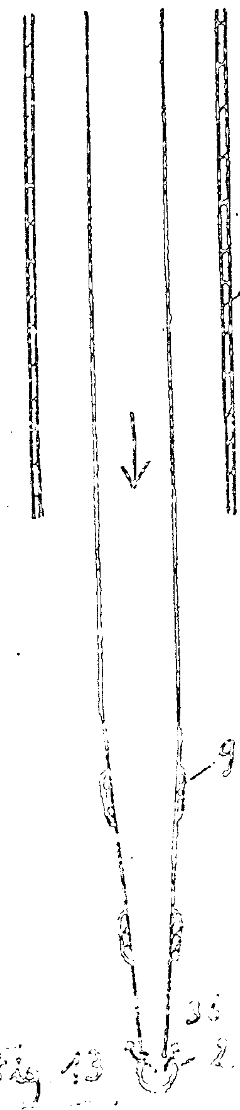
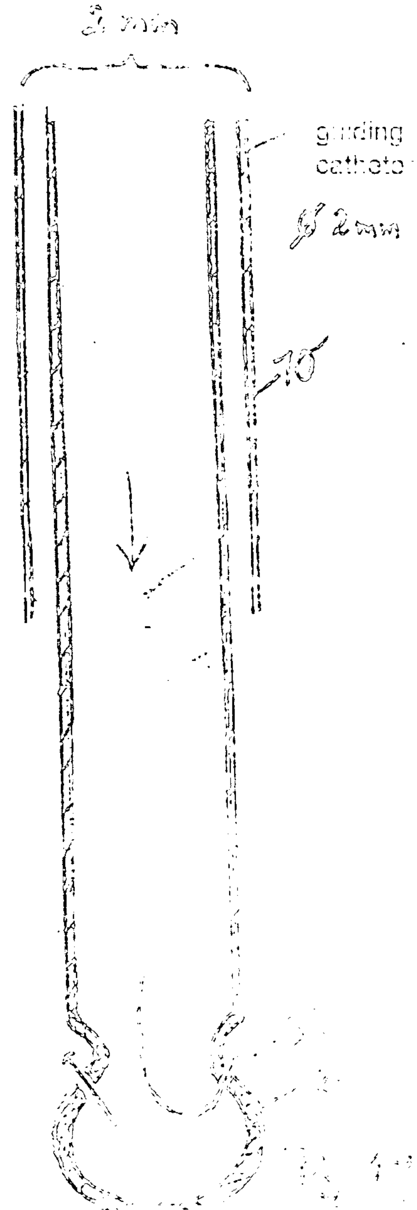


Fig. 13



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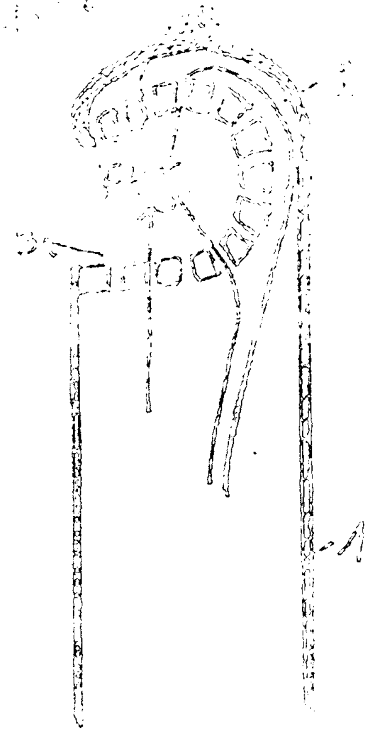

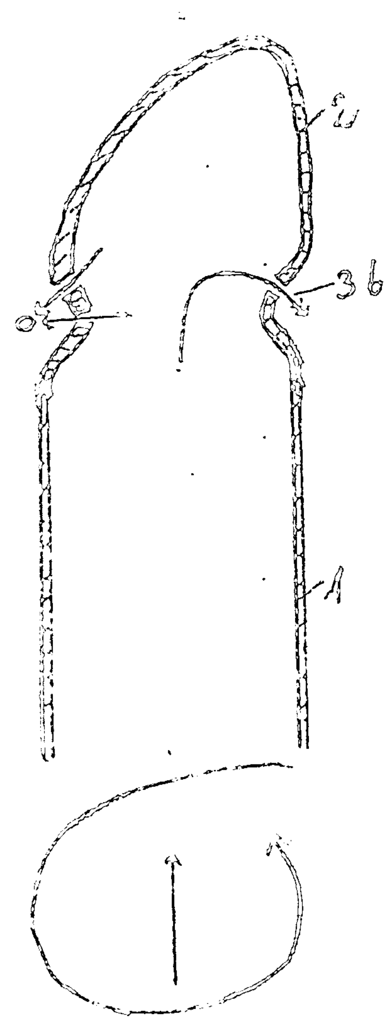

Fig. 17

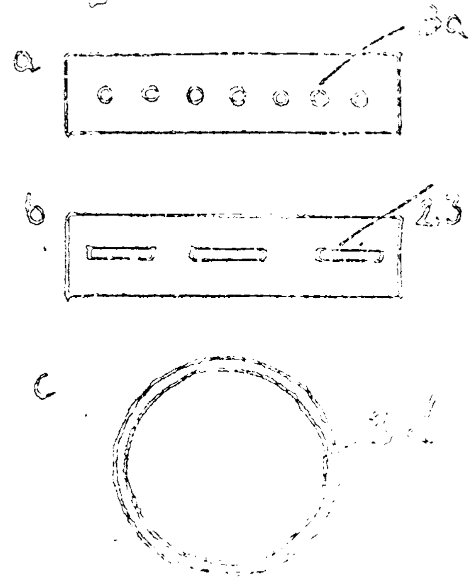

Fig. 18

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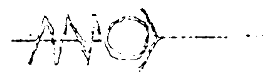


Fig 19

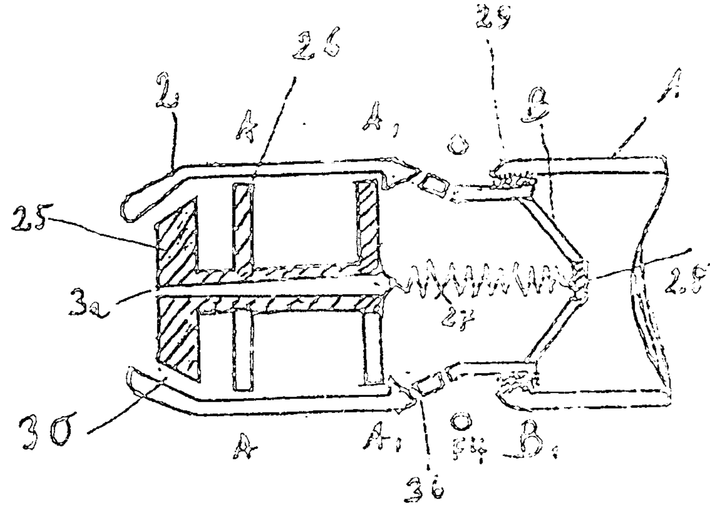
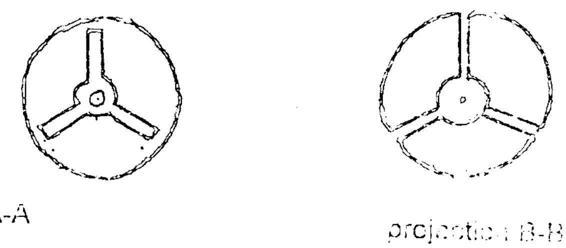


Fig 19 a



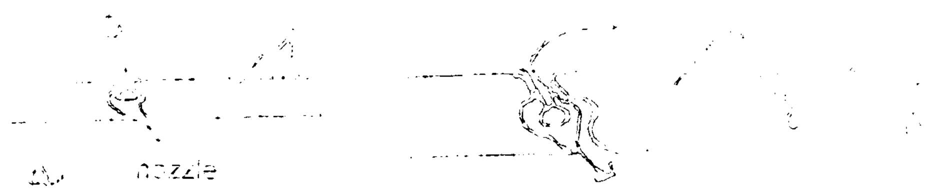


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Fig. 1

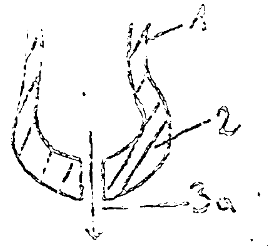


Fig. 2

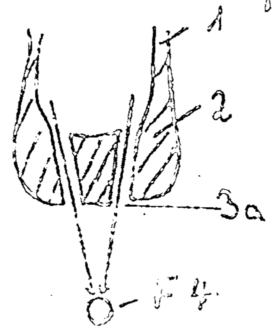


Fig 3

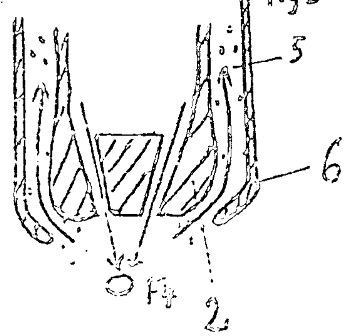
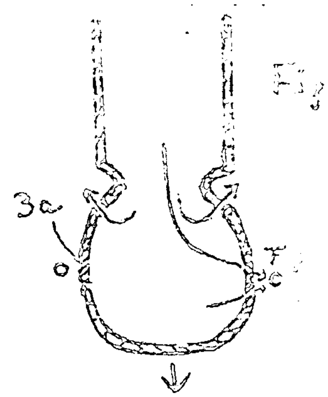


Fig. 4



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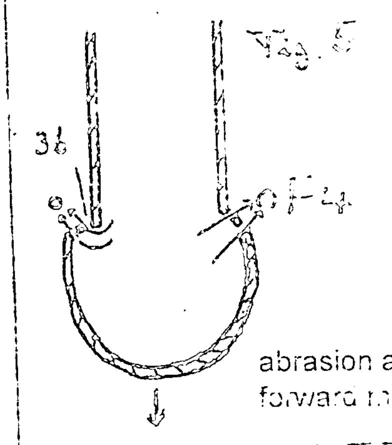

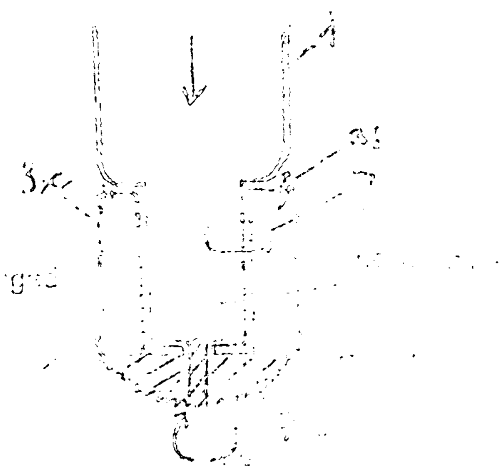

radially impinged

Translator’s notes

The following errors have been corrected in the translation (page/paragraph/lines refer to the German original)

9/3/3 (3)--->(2)

19/2/2 Final numbers in the date are illegible - Not amended in the translation.

35/1/2-4 sich durch ... ergibt ---> sich ... ergeben

38/1/18,20,22,24 Fig. 6, 7, 8, 9 ---> Fig. 9, 10, 11, 12

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